ALUMINUM

Its story

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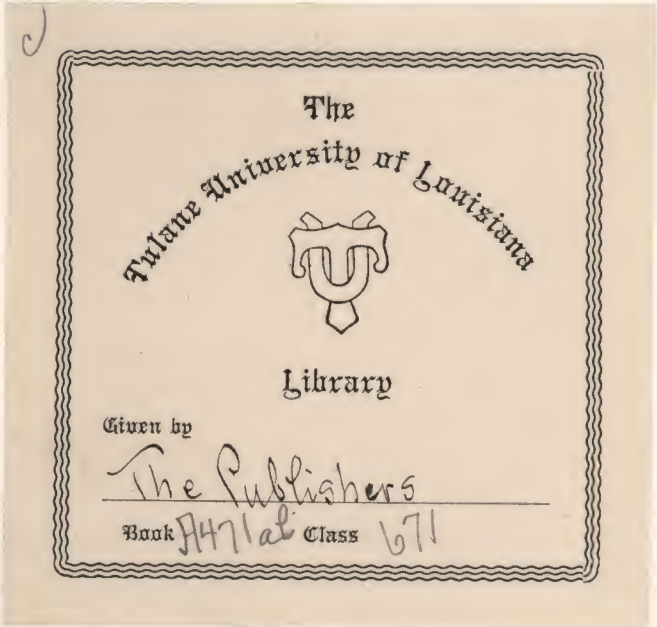

ILLUSTRATED ON THE FRONT COVER

★*Bauxite, the ore of aluminum, found on practically every continent and occurring in many interesting colors and textures.*

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ALUMINUM ☆ *Its story*

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1940

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"Light, strong and versatile, aluminum is by all odds the theme metal of the 20th Century."

LIFE, JUNE 5, 1939

How Industry uses ALUMINUM

CHAPTER ONE ★ ★ ★ ★ ★ ★

PERHAPS YOU will be startled to know that 125 pounds of aluminum are at work for every family in the United States. You don't have that much in your home. But every pound of your 125 is somewhere in the country helping to make your life more enjoyable and cut down your living expenses.

Most of your 125 pounds are used in industry, in the factories that make your shoes and automobile, your chewing gum and match books. Some of your share is in the bus you ride downtown and some is on the farms that give you milk and eggs and flour.

Let us look around through industry and see just a few of the places where aluminum is found. To see all the places would be much too tiresome because there is probably not a single factory, mill or mine in the country that does not have aluminum at work in several different places.

First, take the transportation industry . . . the railroads,

bus and truck lines, steamship companies and air lines. More than 100,000,000 pounds of aluminum, or about a third of all that is consumed in the United States, is used each year in making automobiles, buses and trucks, bicycles and motorcycles, trolley and railroad cars, locomotives, airplanes, motorboats and ships. In fact, this great industry is the largest single user of aluminum.

The big reason for that is the lightness of aluminum. It is easier to get a light vehicle started in motion and takes less fuel, or energy, to keep it going. It can move faster than a heavy vehicle and it can be stopped more readily.

The electrical industry is another large user. It employs

Aluminum contributes to the success of the modern airplane.

Bridges are beautiful by day, safe at night, when protected with aluminum paint.

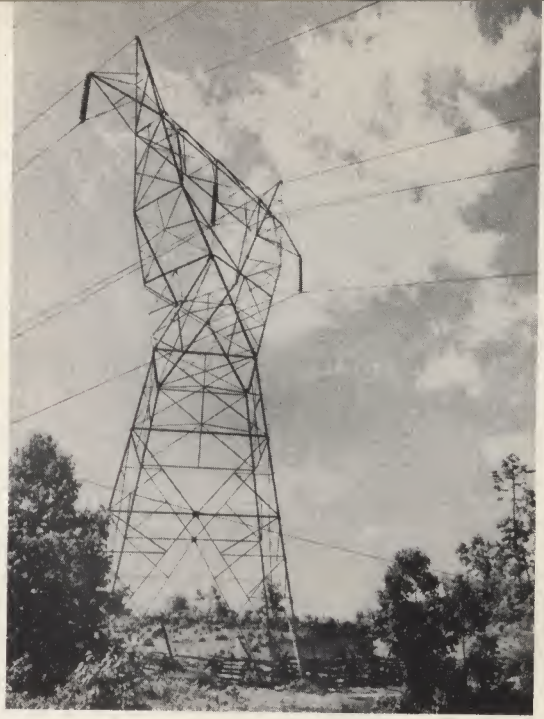
aluminum for carrying electricity from power plants to the user. Many of those "wires" you see looping gracefully from high-voltage towers, and many of those you see strung from poles that carry electricity to farmers, are aluminum cables, steel reinforced. This use of aluminum began in 1897, very soon after the cooking utensil industry got started. Some 750,000 miles of this cable has been strung around the country since that time.

In all kinds of manufacturing plants where great electric motors are used, the power is conducted through large bars of aluminum called bus bars. And in the manufacture of

electrical apparatus and appliances of all kinds, many of the parts are made of this light, shiny metal.

Let's look at building next. In some cases we will have to dig into the walls to find the aluminum but there is much of it right out in the open exposed to the air, rain, sun and cold. On many office buildings, stores and other fine structures you will often see bright shiny doors of aluminum, handsomely designed and decorated. If you look up you may see aluminum spandrels, as they are called, used instead of brick or stone to bridge the space between the top of one window and the bottom of the one above it. The window frames and sills may also be aluminum. So, too, are the frames around many show windows of stores.

Fast stepping all-aluminum streamliner.



Thousands of miles of aluminumhightension transmission lines carry electricity to mills and homes.

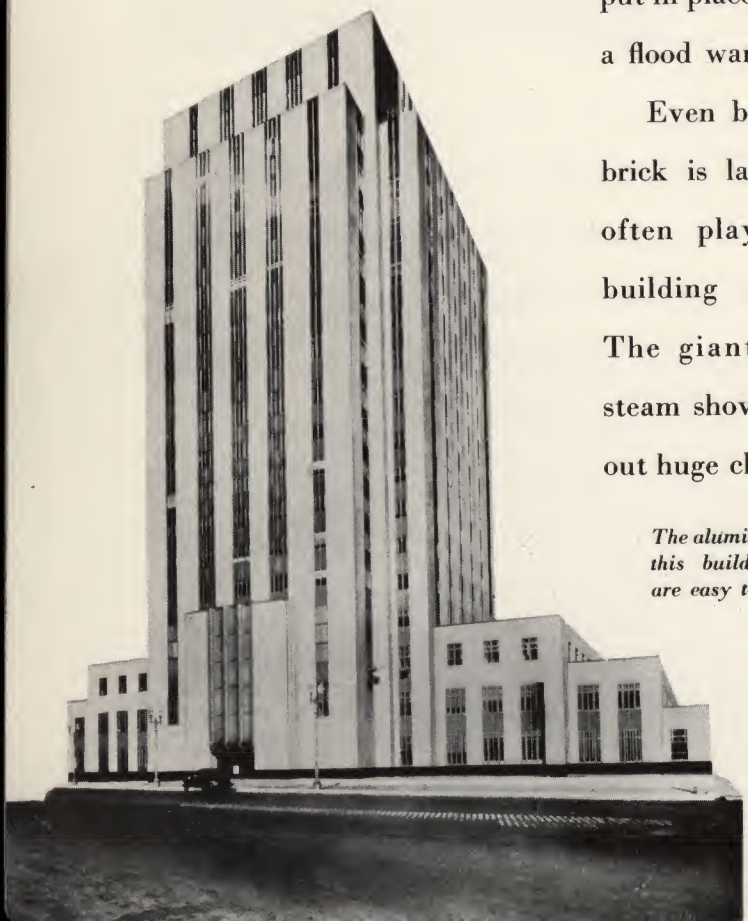
Climb up on the roof and the skylights are likely to have aluminum frames. The roof cresting and cornices, the marquees, facias, mullions and many other parts with strange architectural names are frequently aluminum. Inside you are apt to find aluminum in the stairway or escalator railings and as a decorative trim in many places.

Inside the walls, you may see aluminum conduit carrying the electric wiring to all parts of the building. Also, you may find inside the walls layers of aluminum foil insulation that keep the interior warmer in winter and cooler in summer. And if you scrape away the topcoats of paint on the wood outdoors, you may learn that aluminum paint was used as

the first coat. In factory buildings aluminum paint is applied on walls, ceilings, machinery, stacks, water towers . . . in fact almost any place your eye may light, because this paint is so durable, bright and attractive.

If the building is air conditioned, that opens the way to various other uses of aluminum in the air conditioning system. Some buildings, in places that are frequently flooded, have movable, watertight walls of aluminum that can be put in place quickly when a flood warning is given.

Even before the first brick is laid, aluminum often plays a part in building construction. The giant dippers on steam shovels which eat out huge chunks of earth



The aluminum windows in this building being light are easy to open and close.

for the foundation are frequently made of aluminum. Both lightness and great strength are called for in this service. When they are made of aluminum, the dippers can be bigger and still not be too heavy to swing around and lift. They must be strong, of course, to stand the grinding and bumping against dirt and stones. Other kinds of hoists, booms, and cranes are also built of aluminum to give lightness with strength. Their weights are often cut in half by aluminum, making them cheaper to operate and increasing their capacity.

Large aluminum condenser used in the chemical industries.

In the chemical industry you will find a great deal of aluminum equipment. It is used to manufacture, store and ship hundreds of different kinds of chemicals. The food industry is another big consumer. Canned foods, bakery products, meats, confections and many other foodstuffs are handled in alu-

Ship unloading boom made of aluminum alloy.

minum pails and trays and prepared in aluminum utensils. The fact that aluminum is friendly to food is just as important in these factory-size kitchens as it is in your own kitchen at home. And so is the fact that aluminum distributes heat quickly and evenly, which means better cooking for less money.

Many of the food products you buy, such as cheese, yeast and confections, are supplied to you in a wrapper of aluminum foil that helps to keep them fresh. Other foods that come in bottles, tumblers or jars, such as ketchup, milk, preserves, vinegar and sandwich spreads, come to you

sealed with aluminum caps. These caps keep the contents from spoiling and are easy for you to take off. Drug products and cosmetics that are packed in glass also use millions of these aluminum caps.

Many, many more ways in which industry puts aluminum to work to make things better and cheaper for you could be found if we were to travel around through factories, mills, and mines of all kinds. But let's go home now and see if we can't find aluminum in many places where you don't even suspect you are using it right in your own house.

Aluminum foil, seals, and cooking utensils, protect the purity of foods.

How You use ALUMINUM

CHAPTER TWO ★ ★ ★ ★ ★ ★

OF COURSE the easiest place to find aluminum in the homes is the kitchen. In seven out of eight kitchens there are aluminum pots and pans. But that is just the start of the long list of uses in homes.

Let us suppose that yours is an aluminum "model" home in which all these uses can be found. While we are in the kitchen, let's look in the refrigerator. It has many aluminum parts . . . the ice cube trays and grids, food shelves, interior trimmings, and evaporator. On the shelves are some of those foods, mentioned in the preceding chapter, wrapped in aluminum foil or sealed with aluminum caps.

The kitchen range, either gas or electric, has aluminum parts, too, as has the electric dishwasher. Other appliances that owe much of their efficiency, durability and low cost to aluminum are your waffle "iron," percolator, toaster, food mixer, and electric roaster. Even the kitchen stool is made of aluminum so you can lift it easily. The cleaning closet

Non-tarnishing aluminum accessory items can brighten up any home.

contains a vacuum cleaner that is built very largely of aluminum so you can lift and push it around effortlessly.

Go into the dining room and living room. There you find vases, candlesticks, trays, cigarette boxes, a desk set,

Cooking utensils of aluminum heat quickly and evenly.

It is the speed with which aluminum carries away heat that makes it such an efficient assistant in the freezing of ice.

and ornaments of enduring silvery beauty. They're made of an aluminum alloy specially finished to retain a soft lustre without polishing. Side by side with china dishes and silverware are plates, tumblers, tea and coffee sets, and fruit bowls of this same metal.

At the windows are Venetian blinds with aluminum slats and aluminum parts through which the cord is strung. The lighting fixtures overhead are made of aluminum. Those "silver" stars or dots or stripes in the wall paper are printed with aluminum ink. The "silver" woodwork or decorative trim is done with aluminum paint. The drapes are of aluminum mesh and they hang from hand wrought aluminum rods.

Windows of aluminum are permanently beautiful.

If you lift that chair, don't be surprised at its lightness. Its frame is aluminum. The radio has aluminum condensers and shields that keep it from sputtering and spoiling your favorite program. On the smoking stand in the den is a rack full of briar pipes. In the stem of each one is an odd looking aluminum gadget that makes them smoke drier and cooler. In the telephone, vital parts of aluminum make possible the remarkably clear transmission of your words.

Upstairs, the metal reading lamp by the bed uses aluminum inside the shade to make the light shine brightly on your book. There are aluminum frames around the pictures on the dresser. In the bathroom is an aluminum medicine cabinet. Inside is a bottle containing aluminum hydroxide, a remedy prescribed by the doctor for stomach disorders. There are also some bottles and jars with aluminum caps and shaving cream and tooth paste in aluminum tubes.

Look down the clothes chute. It's aluminum too. Down in the basement are a washing machine, a mangle and an electric "iron". In every one aluminum plays an important part in doing your laundry better, quicker and easier.

Out in the garage, more aluminum in your automobile. It's in the pistons of the motor; in the cylinder head; in the brake pistons. Standing against the wall is a bicycle built of aluminum. Next to it is the big brother to the kitchen stool, an aluminum stepladder.

Looking at the house from outdoors, we see not only aluminum window frames and sills but also aluminum window screens. The fine condition of the paint is accounted for by an undercoat of aluminum paint that was applied when the house was first built.

Not all of these uses of aluminum are found in your home, or in any home. But out of them all . . . and the list could be made longer . . . it becomes plain that this "Theme Metal of the 20th Century" plays a far bigger part in our daily lives than most of us stop to realize.

Aluminum foil insulation keeps the interior of houses warmer in the winter, cooler in the summer.

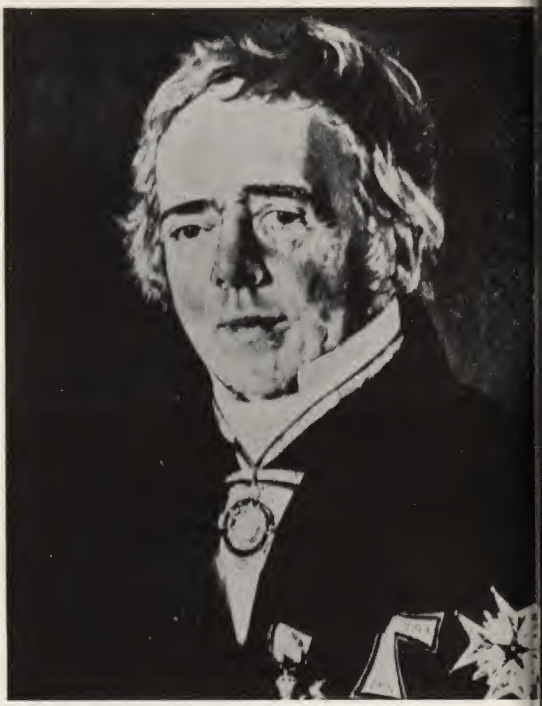
the Birth of ALUMINUM

CHAPTER THREE ★ ★ ★ ★ ★ ★

MEASURED BY TIME, the story of aluminum is a short story. Most of it has happened well within the lifetime of many who will read this account. Aluminum is strictly a modern-day metal.

Although the earth's crust contains more aluminum than iron or copper or lead, 80 years ago aluminum was more precious than even silver and gold. So precious, in fact, that Napoleon III of France, a lover of luxuries, ate with aluminum spoons and forks. Some of his guests, being of lower rank, had to be content with mere gold utensils. Today even the humblest homes use aluminum for the lowly job of cooking potatoes.

With aluminum so abundant, present in every handful of common clay, why has man not known and used it for ages as he has iron and other common metals? Because Nature did such a good job of hiding it in the earth's surface, mixing and disguising it with other elements, that man did



Hans Christian Oersted
1777–1851

not even suspect aluminum existed until a little more than 100 years ago. And after scientists first guessed that there was such a metal, it took them years to find out how to separate it from the stubborn ores in which it is tightly locked.

Some metals are like raisins in bread pudding. They are easy to find and dig out of the earth. But getting aluminum out of the earth is much harder than trying to get back the flour that has been combined with salt, yeast, water and other things used to make the bread in the pudding. Not until 1825 did a Danish scientist, Hans Christian Oersted, succeed in separating a tiny bit of the metal by means of a

chemical process. Aluminum was born, but nobody was interested in the baby.

It wasn't even played with for several years by any other scientists, and not until 1845 did a German, Frederick Wöhler, extract enough of the metal to be worth weighing. He was the first to find that aluminum was light.

Then a French chemist, named Henri Sainte-Claire Deville, became interested. By an improved chemical process of his own, he was able to get enough aluminum to shape into a bar which he exhibited at the Paris Exposition in 1855. He called it "The Silver from Clay." This exhibit attracted the attention of Napoleon III. His first thought was to use the new light metal to make equipment for his soldiers. It would lighten their load so they could march farther and faster. So with the hope that aluminum could be made cheaply and in large amounts, he gave Sainte-Claire Deville money to continue his experiments.

With the French emperor interested and money with which to work, Sainte-Claire Deville improved his process. However, after working four years he could produce but two tons of aluminum a year and the price was $17 a pound. That was still not enough and still too expensive for equip-

ping an army, so Napoleon could use the new metal for jewelry and novelties only. The baby was still a baby . . . but other scientists were soon to become interested in it.

One of them was a young American—Charles Martin Hall who while still in Oberlin College in Ohio, read of Sainte-Claire Deville's work. He became intrigued with the thought that there must be some way of making aluminum more cheaply than by the Frenchman's process.

So young Hall set out to find the secret that had eluded man since the beginning of time.

Charles Martin Hall
1863–1914.

At first he, like the Danish, French and German scientists, tried chemical processes for obtaining aluminum. One day, after many disappointments, he had a

Paul Louis Toussaint Héroult
1863–1914

novel and wonderful idea that if he could find a liquid in which aluminum oxide would dissolve, then he could pass an electric current through the solution and obtain metallic aluminum.

On February 23, 1886, Hall melted a bit of cryolite in a small crucible and discovered that aluminum oxide would dissolve in it. He then turned on the electric current and found that aluminum slowly formed in the bottom of his crucible. At the age of 22 he had found the answer to Nature's puzzle. He had found the way to make aluminum, lots of it, cheaply. The baby had won its birthright.

Oddly enough, at the same time as Hall was making his discovery, Paul Louis Toussaint Héroult, a Frenchman, discovered the same electrolytic process for making alu-

minum. Neither knew anything of the other's work. Both were the same age. In fact, so similar were their destinies that both these men died within a few months of each other in 1914.

In 1886, the year of Hall's discovery, all the aluminum produced in the world amounted to but 17½ tons and its price was $8 a pound. In 1938 the world production amounted to 644,761 tons, nearly 37,000 times as much, while the price of aluminum today has been brought down

The Crown Jewels of the aluminum industry. The small nuggets were made by Hall with a galvanic battery in 1886; the large pellet is the first commercial aluminum made by the electrolytic process.

to approximately 20 cents a pound, a 4,000 per cent reduction. All this in 50 years.

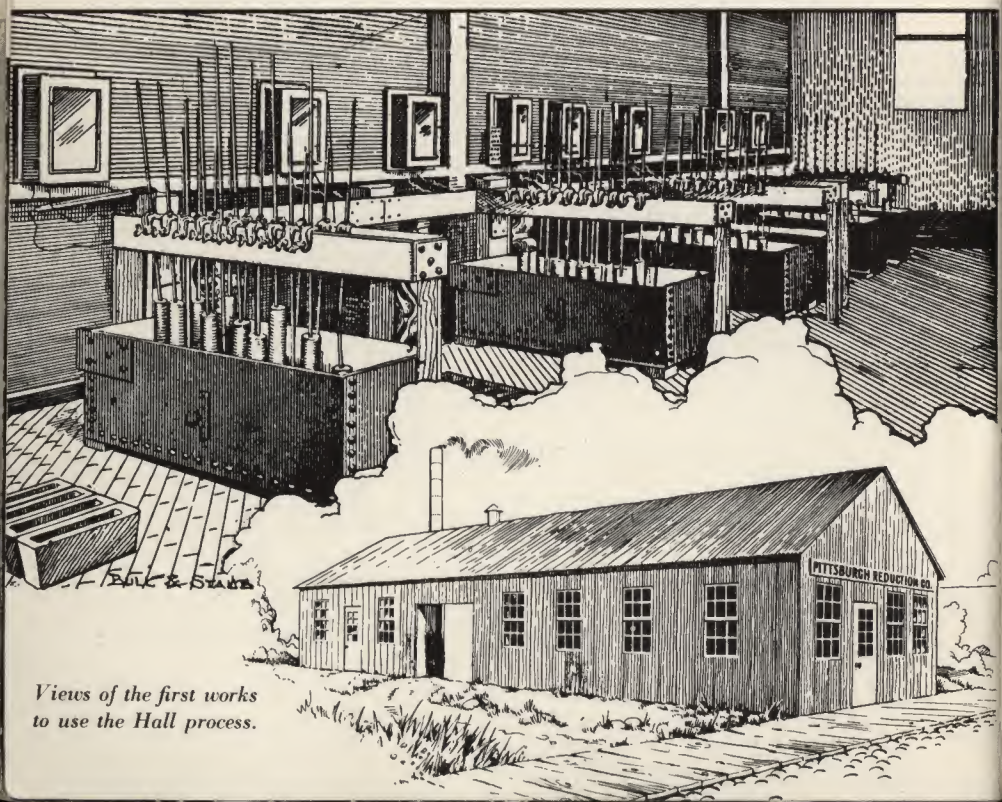
But the first of those fifty years were hard ones for the infant industry. Except to scientists and a few manufacturers of novelties, aluminum was not well known. Even when its price came down to $2 a pound in 1,000 pound lots, little interest was aroused among possible users.

It seems that the first article made from aluminum that had been produced in the United States was a transit, an instrument used by surveyors. This was made in 1876, ten years before Hall learned how to make aluminum cheaply. In 1884 the Washington monument was fitted with a small aluminum cap that is still perched securely on its pyramid top. This aluminum cap was such a novelty in 1884 that it was put on exhibition at Tiffany's, the famous New York jeweler's, before it was set in place. For 55 years it has been exposed to all kinds of weather, yet it remains today unharmed by the elements.

After Hall's discovery, there was an increase in the manufacture of aluminum novelties. These included such things as watch cases, collar buttons, tea balls, salt and pepper shakers, combs, bookmarks, paper cutters, looking

glass and picture frames, hairpins, penholders and house numbers. Most important of the early products, however, were aluminum cooking utensils. This use grew steadily and healthily until today more aluminum cooking utensils are used in American homes than any other kind.

Although they seemed promising at the time, many of the early uses proved unsuccessful when it come to actual manufacture of the articles. But each failure was a stepping stone of knowledge. Out of them grew the successful uses of later years.



Views of the first works to use the Hall process.

From Earth to INGOT

CHAPTER FOUR ★ ★ ★ ★ ★ ★

IT WOULD BE POSSIBLE to get aluminum out of your own backyard if your soil contains much clay. But it wouldn't be worth while. It would cost too much to separate the aluminum from the clay. Rich ores, which are plentiful, provide a cheaper source.

At present the only ore used commercially in the United States is called bauxite. It contains aluminum in the form of aluminum hydroxide, which is a chemical combination of aluminum, hydrogen and oxygen. In addition, bauxite contains a number of impurities. Because of them, bauxite occurs in various colors and textures, depending on the amounts and kinds of impurities that are present. Some bauxite is white, some red, some yellow. Or it may be found in all possible combinations of these colors, often quite pretty. Bauxite may be like rock or as soft as mud.

Bauxite deposits are known to exist in Africa, Asia, Australia, Europe and North and South America with the

principal bauxite producing countries being the United States, France, Hungary, Italy, Yugoslavia, Surinam (Dutch Guiana), British Guiana, U.S.S.R., Netherland India and Greece. In the United States, Arkansas ore is used in the production of aluminum although ore deposits are also found in Alabama, Georgia, Mississippi, Tennessee and Virginia.

Bauxite is used for other things beside making aluminum. About half of what is mined in this country is used for manufacturing chemicals, grinding wheels and stones, and high temperature insulating materials.

The underground mining of bauxite.

Open-pit mining of bauxite.

Some of the beds lie close enough to the surface to be mined by the "open pit" method, which simply means removing the dirt and gravel that lies above the ore, and then digging out the ore itself. Other beds are so deep that shafts and tunnels have to be dug in order to reach and remove the ore. The mining methods, for either type of deposit, are much the same as those used for other minerals.

The bauxite comes out in chunks of all sizes. Mixed with

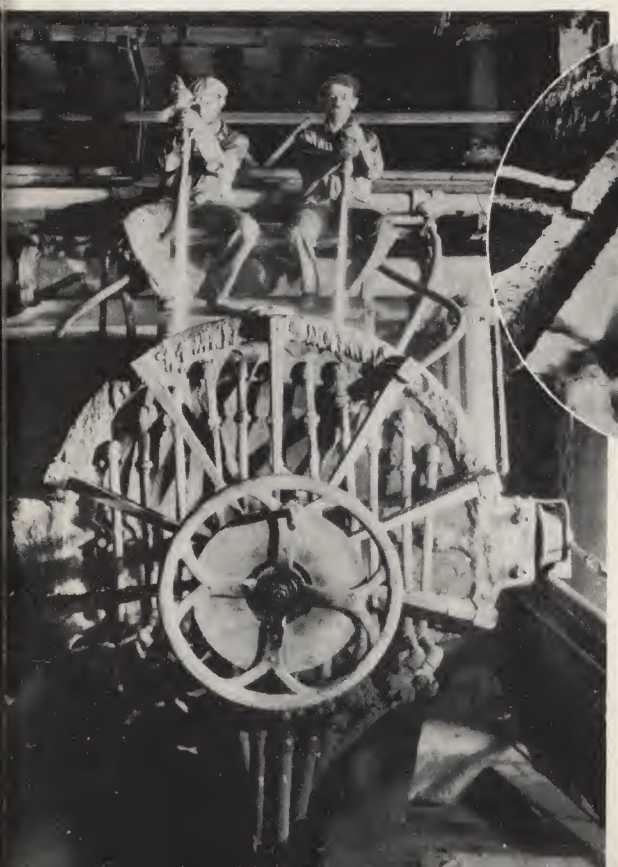
Washing and screening bauxite.

it are dirt and other loose impurities. These materials are removed by washing and screening at a nearby mill. There the ore is also broken up by powerful crushers into pieces no larger than a walnut. After it has been thoroughly dried in great kilns, the ore leaves its birthplace by ship or train and goes to other plants to be refined.

There are a number of different ways to refine bauxite. Of these, the Bayer process, named for its discoverer, Karl

Josef Bayer, is used most commonly. In this process the bauxite is first crushed to a powder and then mixed, in large pressure tanks, with a hot solution of caustic soda. The caustic soda dissolves the aluminum hydroxide but not the impurities, just as coffee dissolves sugar but won't dissolve buckshot. The solution is now filtered and the impurities in the form of red mud are left behind.

This solution is then pumped into great tanks that tower into the air. As it slowly cools, pure aluminum hydroxide



Above: Sodium aluminate solution pouring into a large precipitator.

Left: Large filter press removing impurities from ore.

settles out in the form of fine crystals. The aluminum is still combined with oxygen and hydrogen. The crystals are washed with water to remove the caustic soda and are then ready for step number two in the process.

This second step is comparatively simple. The aluminum hydroxide crystals are fed into large revolving kilns and heated until white hot. The heat drives off all the chemically combined water in the form of steam. What is left is a white powdery chemical, still not pure aluminum. It is aluminum oxide, more commonly called alumina. Four pounds of bauxite are needed to make two pounds of alumina, and these two pounds will yield but one pound of aluminum.

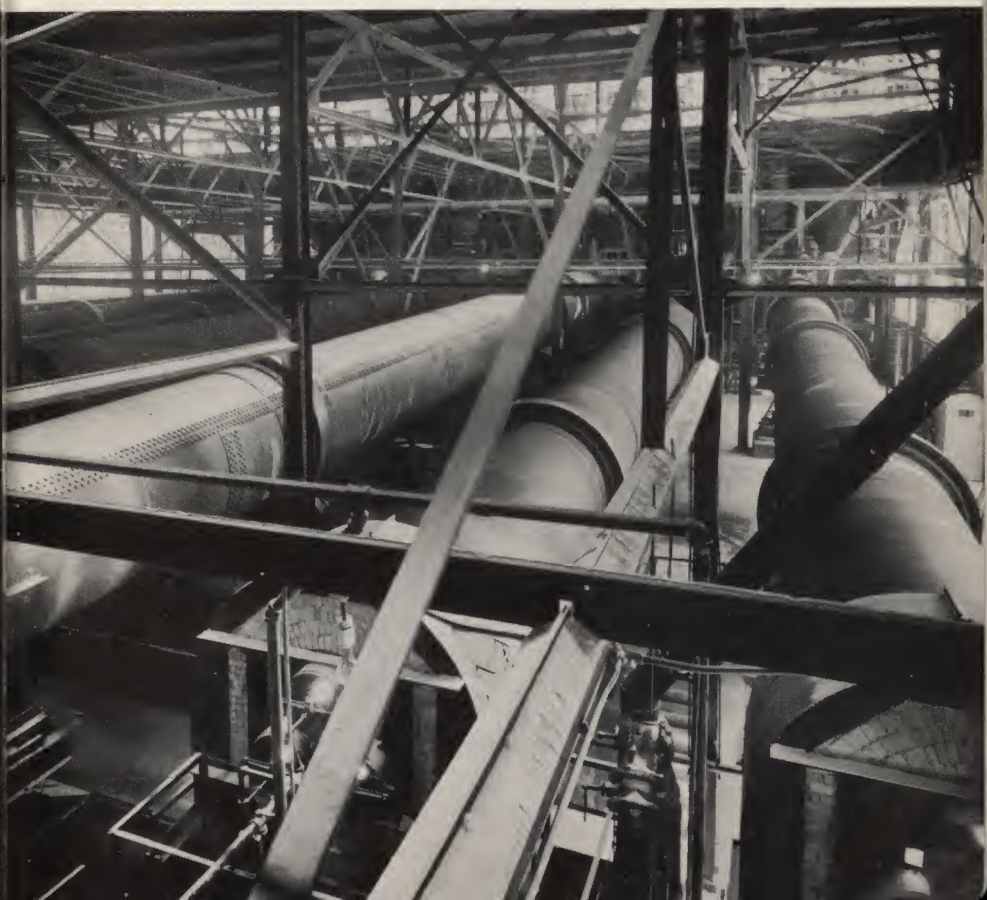
The third and last step is to pry the aluminum loose from the oxygen that is combined with it in the powdery alumina. It is the secret to this vital step that Hall discovered in his father's woodshed, and Héroult discovered at the same time in France. It is their discovery which has made aluminum cheap enough for you to use for pots and pans and paint.

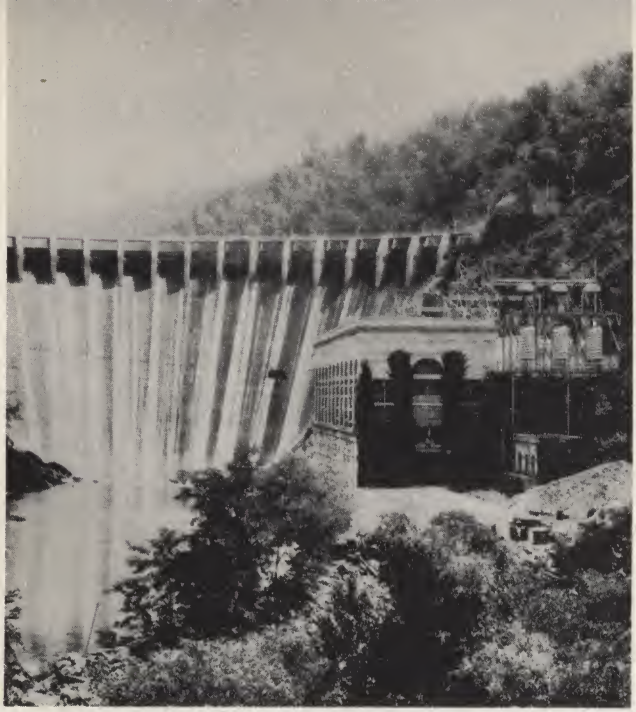
But it requires a tremendous investment in power dams, electric generating plants and electric furnaces, for electricity is the key to the lock that imprisons aluminum. So the reduction plants, as they are called, must be located in places

where electricity is plentiful. As a matter of fact to make one ton of aluminum enough electricity is used to keep a 40 watt light bulb burning for 68½ years.

Also needed for the process is a material called cryolite. The Eskimos in Greenland, where cryolite is found, named it "ice stone" because it looks like frozen snow. Though it is found naturally in Greenland, cryolite can also be manufactured chemically. Either kind, the natural or manufac-

Calcining kilns used to convert aluminum hydroxide into alumina.





One of the many power dams needed to supply electric current for the production of aluminum.

tured cryolite, may be used in the production of aluminum.

The reduction process is carried on in electrolytic cells. These cells are built of steel and are lined with carbon. Hung in them from above are large blocks of carbon, called electrodes. There are long rows of these cells in a reduction plant, each one being able to turn out about 250 pounds of aluminum a day.

The cell is first filled with cryolite. Then the electricity is turned on. When the electric current has melted the cryolite, the powdery alumina is added and is soon dissolved in the cryolite bath. The current enters the cryolite bath

through the suspended carbon blocks and leaves through the carbon lining. Alumina, you will remember, is aluminum chemically combined with oxygen. The electric current breaks up this combination. It sets the oxygen free at the carbon electrodes and the aluminum is deposited in a molten layer at the bottom of the furnace. From time to time it is

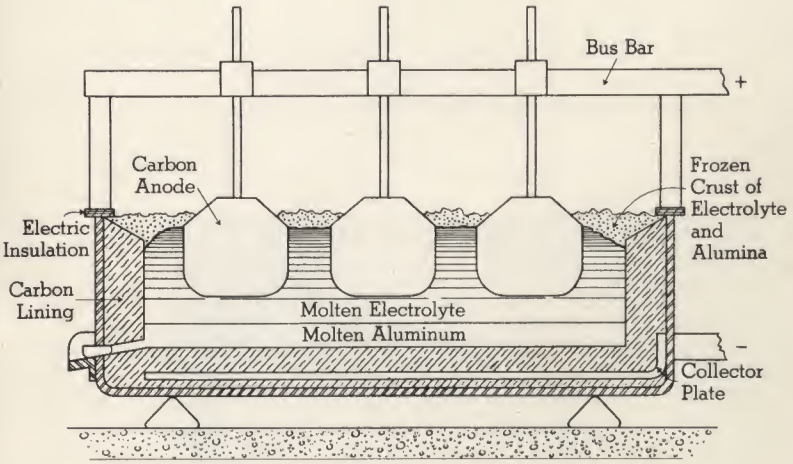


Diagram of an electrolytic cell.

drawn out into large ladles and is poured into molds to cool. It is now metallic aluminum, and is in a form called "pigs."

The molten cryolite bath in the furnace is not changed in any way by all the electrical and chemical magic. As the molten aluminum is drawn off at the bottom, more alumina is added to the bath. And so the process goes on.

However, the pigs contain a small amount of dross and electrolyte which comes out of the bath with the molten aluminum. Before the metal can be used for manufacturing purposes, the pigs are remelted to get rid of this impurity, after which the remelted aluminum is poured into other molds to cool. At this point it is called aluminum ingot, the bulk form in which it is sold to industry for making aluminum products. All in all it takes 18,000 pounds of raw materials to produce one ton of aluminum.

Pouring an aluminum "pig."

What's the DIFFERENCE

CHAPTER FIVE ★ ★ ★ ★ ★ ★

NOW THAT WE have finally pried aluminum loose from its ore and have shaken off all the impurities that were hanging onto it, let us stop and see what we have. What kind of a metal is it? How is it different from other metals, from iron and copper and zinc? What are some of the things that can be done to it? When these things are known, we will have a better idea of what aluminum can be used for.

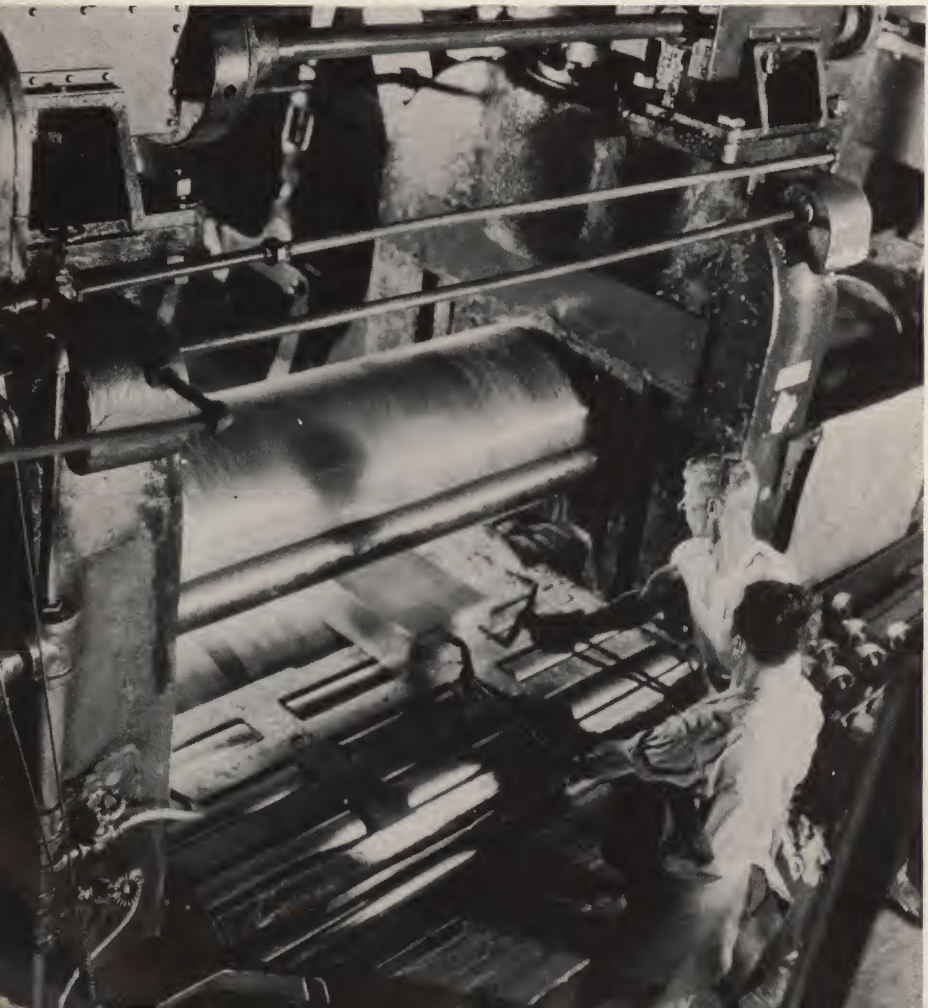
When you look at a piece of shiny aluminum, you are reminded of silver. The two metals have much the same color, except that there is a distinctive bluish tinge in the silvery whiteness of aluminum.

You have only to pick up a piece of aluminum and you realize that it is much lighter than most metals. A cubic inch weighs very close to one-tenth of a pound. That is only about a third the weight of iron, steel, copper or brass. It means that you get three times as big a piece of metal in a pound of aluminum as in a pound of other common metals.

Another thing about aluminum that is known to every housewife is the fact that it spreads heat quickly and uniformly. That is one of its advantages for cooking.

Electricity, too, is carried very easily through aluminum. Other interesting points about the metal are: It does not rust; it strongly resists corrosion; and it reflects light and

An ingot goes through the rolls.



heat very effectively. All of these qualities are used in one or more ways in the countless jobs that aluminum does for you in the world today.

Rolling aluminum foil.

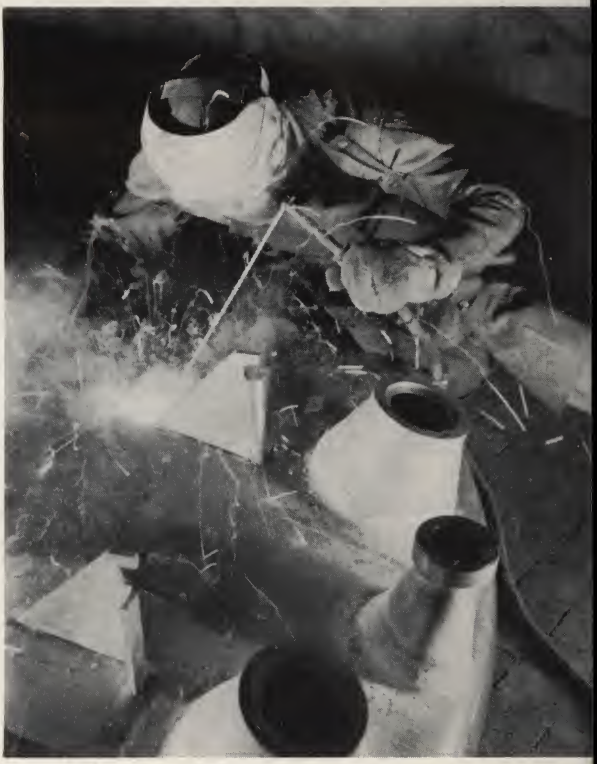
In addition to all these qualities is the fact that aluminum is so easily made into all kinds of things. It lends itself to every known process for shaping things from metal. In fact, no other metal can be had in so many different commercial forms as aluminum. It can be melted and poured into molds of all shapes and kinds. It can be rolled, either hot or cold, into thick plates, flexible sheets, or into foil so thin that ten layers are needed to equal the thickness of newspaper. Or it can be rolled into bars, rods and various other shapes that are used in building trains, planes and ships. It can be drawn out in a wire so fine it can hardly be seen with the naked eye, many times finer than a human

hair. It can be stranded, like rope, into cables. It can be pressed, stamped, hammered, turned and handled in all the other ways that modern industry employs to make things of metal. It is even "squirted," under terrific pressure, into the form of the tubes in which your tooth paste and shaving cream come.

Sometimes small amounts of other metals are mixed with aluminum to make it stronger. These mixtures are called aluminum alloys. Copper, silicon, manganese, magnesium, and chromium are the metals most commonly used in aluminum alloys. The strength of certain of these can be increased further by heat-treatment. Some of these heat-treated alloys have the strength of mild steel. Others are

Roll-forming an aluminum tank.

used not so much for their strength as for their greater hardness or because they are easier to work with in certain manufacturing processes. There are ever so many of these aluminum alloys, and they have greatly increased the usefulness of aluminum.



Metallic arc welding of aluminum.

Now let us add up the things which make aluminum necessary in our daily lives—so necessary that every family in the country has 125 pounds of aluminum working for it somewhere: Nature made aluminum light, made it carry heat and electricity, made it reflect heat and light, made it rustproof, and made it easy to work with in factories. Man has made it cheap and plentiful and strong. But all of these reasons why aluminum is widely used can be summed up in a single reason: Aluminum is bought and used for many things because it makes them cheaper or better.

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